Does Easterly wave activity increase after the interaction with Convectively Coupled Kelvin Waves?

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Objectives

Our study tries to understand the role of Convectively Coupled Kelvin Waves (CCKW) in modulating (increase/decrease/no effect) the African Easterly Wave (AEW) activity:

- Does CCKW modulate AEW activity?
- What are the underlying mechanisms that cause the intensification (if any) of AEW activity during the interaction with CCKW?

Overview

Past studies (Mekonnen 2008, Ventrice, M.J 2013) have proposed AEW activity is enhances over east Atlantic and West Africa after the passage of CCKW. However the details of this process are yet to be investigated in detail. For instance, AEW activity is organized into two distinct but interacting stormtracks - A northern low-level (925-850 hPa) track and a southern mid-level track (700-600 hPa). The southern track is convectively active while the northern track depends on dry baroclinic growth. It is not clear which stormtrack is modulated and to what extent by the passage of Kelvin waves.

In this ongoing study, we will establish whether there is a statistically significant increase in AEW activity by examining mutiple wave parameters and locations over the Atlantic-Africa sector. Second, we will try to establish which part of the AEW stormtrack is intensified after interaction with the CCKW and what underlying mechanisms are active.

AEWs are important precursors disturbances genesis of hurricanes in the Atlantic and eastern Pacific. Therefore, improvement in our understanding of AEW-CCKW interaction will in predictability of hurricanes.

Data

Data used in this study include:

- ERA Interim reanalysis wind fields (D. P. Dee et al (2011))
- Outgoing Longwave Radiation (OLR): Data provided by the NOAA/OAR/ESRL PSD, Boulder, Colorado, USA, from their Web site at https://www.esrl.noaa.gov/psd/
- NASA Tropical Rainfall Measuring Mission (TRMM) Multisatellite Precipitation Analyses (TMPA, TRMM product 3b42) (Huffman et al. 2007)
  Data period: 1998-2016

Method

Filtering:

OLR, winds, and TRMM rainfall estimates are filtered in zonal wavenumber and frequency following previous studies by Kiladis et al. (Wheeler and Kiladis 1999; Straub and Kiladis 2002). The Kelvin wave filter is bounded by eastward-propagating zonal wavenumbers 1-14, periods of 2.5-20 days, and the shallow-water dispersion curves for equivalent depths of 8 and 90 m (Straub and Kiladis 2002). The easterly wave filter is bounded by westward-propagating zonal wavenumbers -26 to -6, periods of 2-10 days.

Compositing:

Following the methodology of Ventrice et al. (2012a,b), an index (hereafter the CCKW index) was developed by selecting all dates between June–September (JJAS) 1998 and 2016 when the minimum negative Kelvin-filtered OLR anomaly (less than 1.5 standard deviations in magnitude) was over a selected grid point (10^oN, 15^oW). We pick the same base point as Ventrice et al. (2012a,b) for consistency. A total of 110 CCKWs were objectively identified using this methodology. Lags were then used on this time series in order to examine propagating characteristics. For clarification, Lag 0 is when the minimum negative Kelvin-filtered OLR anomaly moves over the selected base point.

Results

Compositing of easterly wave filtered EKE based on different base points:

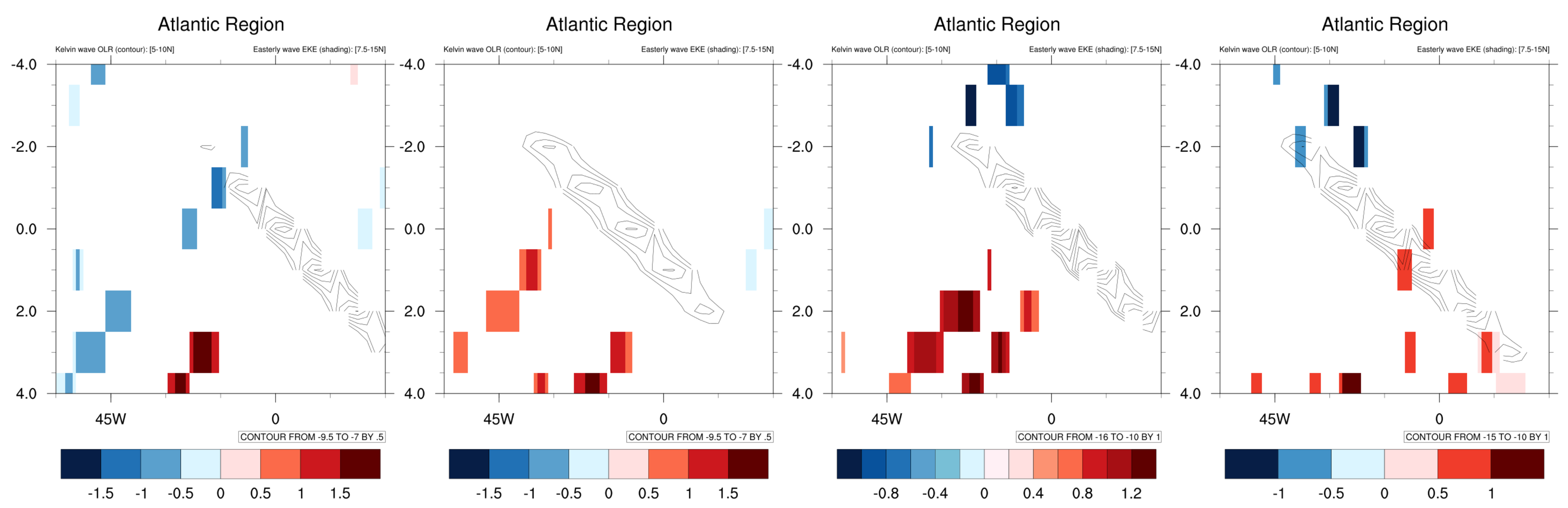

Figure 1: Hovmoller plots of easterly wave filtered EKE (shading) [600 mb] composited with Kelvin filtered OLR (contour) for different base Points a) 0N 0E b) ON 15W c) 10N OE d) 10N 15W. Values are contoured and shaded if statistically different than zero at the 95% level

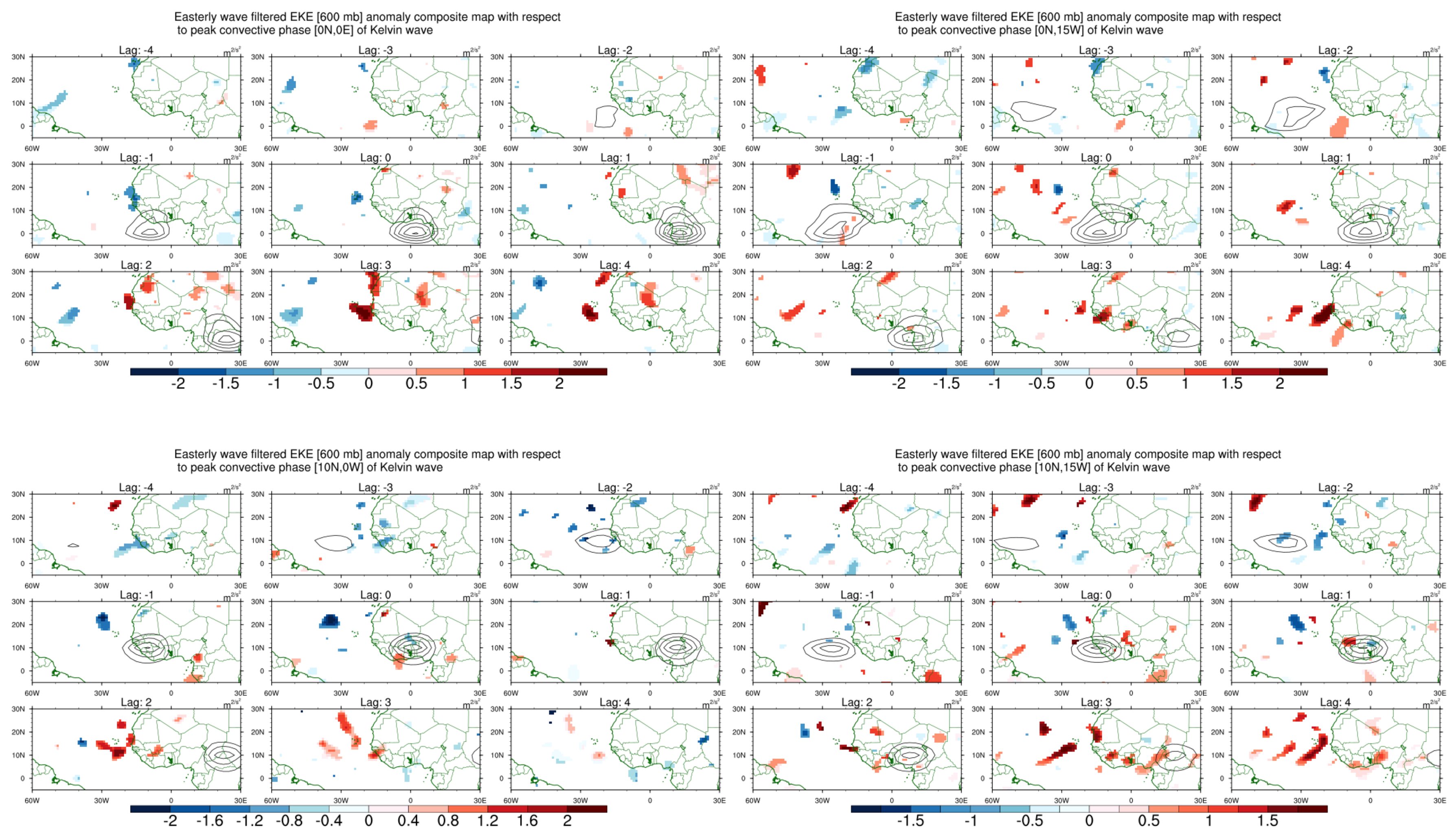

Figure 2: Composite spatial maps of easterly wave filtered EKE (shading) [600 mb] composited with Kelvin filtered OLR (contour) for different base Points a) 0N 0E b) ON 15W c) 10N OE d) 10N 15W. Values are contoured and shaded if statistically different than zero at the 95% level. Kelvin filtered OLR contour interval is 2 w/m^2

Compositing of easterly wave filtered TRMM rainfall rate for base point 10N 15W

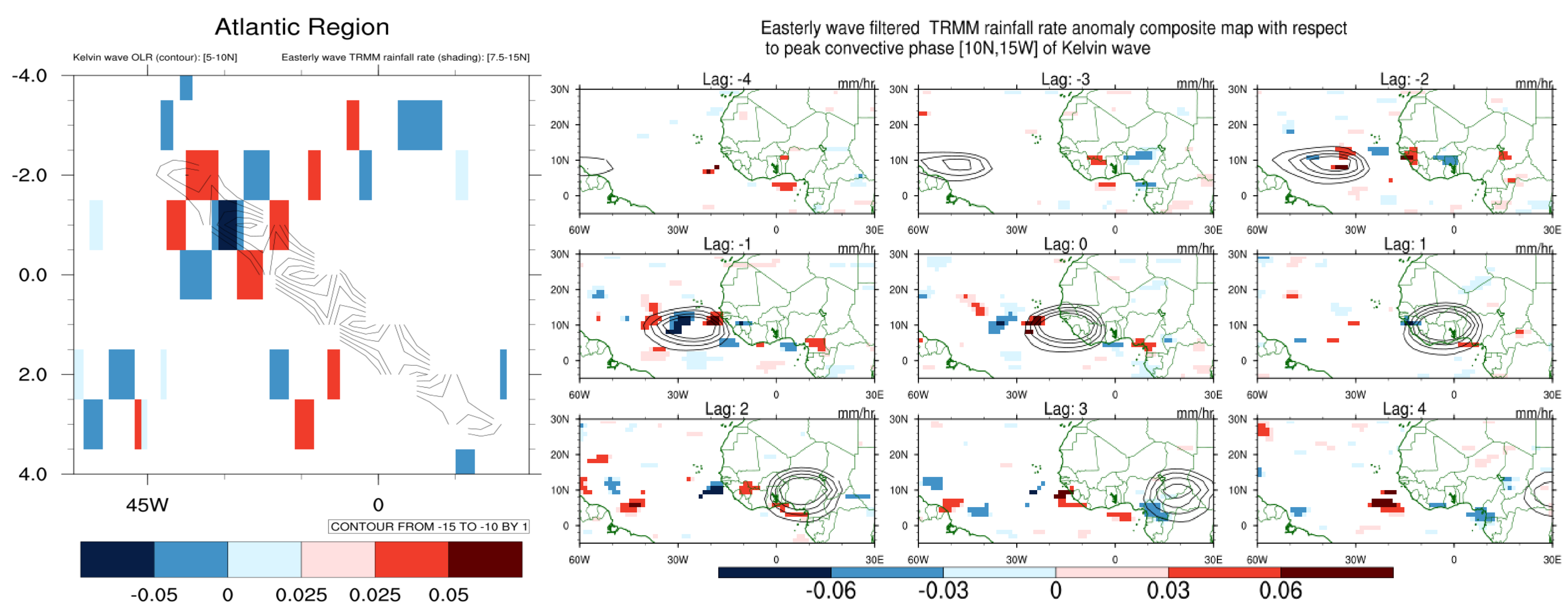

Figure 3: a. Hovmoller plot of easterly wave filtered TRMM rainfall rate (shading) composited with Kelvin filtered OLR (contour). b) Composite spatial map of easterly wave filtered TRMM rainfall rate (shading) composited with Kelvin filtered OLR (contour). Values are contoured and shaded if statistically different than zero at the 95% level

Compositing of easterly wave filtered OLR for base point 10N 15W

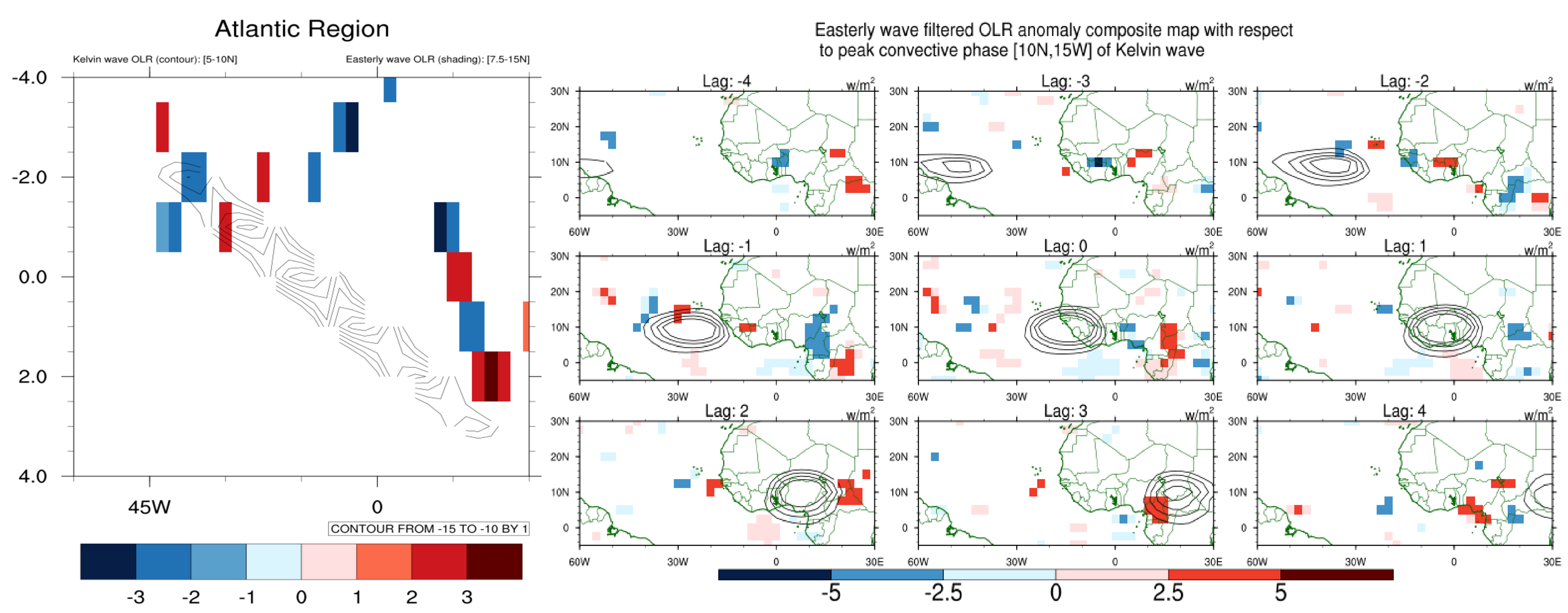

Figure 4: a. Hovmoller plot of easterly wave filtered OLR (shading) composited with Kelvin filtered OLR (contour). b) Composite spatial map of easterly wave filtered OLR (shading) composited with Kelvin filtered OLR (contour). Values are contoured and shaded if statistically different than zero at the 95% level

Conclusion

- Composite analysis of easterly wave filtered EKE for different base points shows different results and there is no consistency between them.
- Increase in EKE is evident only in the hovmoller plot with base point 10N 0E.
- Also, Inconsistency is evident in the EKE composite spatial maps. Generally the increase in EKE should be only to the South of African Easterly Jet (AEJ) (15N) since we are looking at eke at 600 mb, but there is increase in EKE to the North of 15N.
- Easterly wave filtered rainfall rate and OLR doesn't increase or do not show any consistent trends in the hovmoller and spatial maps.
- The above results may suggest not so significant role of CCKW in modulating AEW activity.

Additional Information

Mechanisms influencing the interaction:

- Ventrice (2013) proposed two possible mechanisms through which AEW activity can increase. First, the increase in AEW initiation can be attributed to increase in the frequency of long-lasting MCSs. The CCKW increases the anomalous easterly shear a known condition that is beneficial for strong and long-lasting MCS development.
- Second, by making AEJ more unstable through enhanced vorticity gradients associated with CCKW.

Future Work

- To bolster the results we will do analytical and numercial study using the Weather Research Forecast (WRF) model and idealized simulations using an intermediate complexity general circulation model.
- In the full-physics WRF simulations, we will remove the Kelvin waves from the reanalysis data and initialize the model and see if there is increase in AEW activity.
- We will also investigate the proposed mechanisms for AEW-CCKW interaction through idealized and real-case simulations.

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